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(54) **Balloon-actuated stent with interlocking elements**

Ballonbetätigter Stent mit verriegelbaren Elementen

Stent avec éléments de verrouillage actionné par ballon

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Description

[0001] The present invention relates, in general, to intraluminal medical devices, and, more particularly, to a new and useful stent, and stent delivery apparatus.

[0002] A stent is commonly used as a tubular structure left inside the lumen of a duct to relieve an obstruction. Commonly, stents are inserted into the lumen in a non-expanded form and are then expanded autonomously (or with the aid of a second device) *in situ.* When used in coronary artery procedures for relieving stenosis, stents are placed percutaneously through the femoral artery. In this type of procedure, stents are delivered on a catheter and are either self-expanding or, in the majority of cases, expanded by a balloon. Self-expanding stents do not need a balloon to be deployed. Rather the stents are constructed using metals with spring-like or superelastic properties (especially nickel titanium based alloys), which inherently exhibit constant radial support. Self-expanding stents are also often used in vessels close to the skin (i.e., carotid arteries) or vessels that can experience a lot of movement (i.e., popliteal artery). Due to a natural elastic recoil, self-expanding stents withstand pressure or shifting and maintain their shape.

[0003] As mentioned above, the typical method of expansion for balloon expanded stents occurs through the use of a catheter mounted angioplasty balloon, which is inflated within the stenosed vessel or body passageway, in order to shear and disrupt the obstructions associated with the wall components of the vessel and to obtain an enlarged lumen.

[0004] Balloon-expandable stents involve crimping the device onto an angioplasty balloon. The stent takes shape as the balloon is inflated and remains in place when the balloon and delivery system are deflated and removed.

[0005] In addition, balloon-expandable stents are available either pre-mounted or unmounted. A pre-mounted system has the stent already crimped on a balloon, while an unmounted system gives the physician the option as to what combination of devices (catheters and stents) to use. Accordingly, for these types of procedures, the stent is first introduced into the blood vessel on a balloon catheter. Then, the balloon is inflated causing the stent to expand and press against the vessel wall. After expanding the stent, the balloon is deflated and withdrawn from the vessel together with the catheter. Once the balloon is withdrawn, the stent stays in place permanently, holding the vessel open and improving the flow of blood.

[0006] In the absence of a stent, restenosis may occur as a result of elastic recoil of the stenotic lesion. Although a number of stent designs have been reported, these designs have suffered from a number of limitations. Some of these limitations include premature deployment of the stent due to circumstances such as over-manipulation when traversing tortuous vessels or the inability to maintain the stent secured to the balloon due to migration, slippage, etc.

[0007] Accordingly, to date, there have not been any stent designs, that specifically address these drawbacks in an efficient and cost effective manner.

[0008] DE-A-19728337 discusses a stent which can be locked in an expanded configuration.

[0009] According to the present invention there is provided an apparatus for stenting a vessel as defined in appended claims 1 and 2.

[0010] The present invention relates to an apparatus and method for stenting a vessel in conjunction with a particular new and useful stent having a lattice of interconnecting elements defining a substantially cylindrical configuration. The lattice has a first open end and a second open end wherein the lattice is movable between a locked configuration and an open configuration.

[0011] One embodiment of the stent includes a plurality of bridges connecting the interconnecting elements wherein each bridge interlocks with an adjacent bridge in the locked configuration and wherein each bridge separates from the adjacent bridge in the open configuration.

[0012] In another embodiment, the interlocking elements include a plurality of struts wherein each strut interlocks with an adjacent strut in the locked configuration and each strut separates from the adjacent strut in the open configuration.

[0013] For the interlocking bridge embodiment, each bridge has a projection and a base wherein the base has a projection holding section for receiving the projection from an adjacent bridge. Likewise, for the interlocking strut embodiment, each strut has a projection and a base wherein the base has a projection holding section for receiving the projection from an adjacent strut. Accordingly, for both of the stent embodiments identified above, several features are in common. For instance, the interlocking elements comprise a plurality of adjacent sections. Additionally, the adjacent sections comprise adjacent hoops wherein each hoop comprises a plurality of loops. Each loop comprises at least one strut.

[0014] For both the interlocking bridge embodiment and the interlocking strut embodiment, lateral arms extend from the base. Moreover, the projection holding section of the base has an opening therein for receiving the projection. An extension is connected between the base and the projection, and, for the interlocking bridge embodiment, the extension includes a neck wherein the projection is located at a superior position on the neck.

[0015] The projection also includes at least one lateral lip and the projection holding section includes at least one lateral ledge for releasably engaging the at least one lateral lip of the projection. The projection also includes at least one sidewall adjacent to the at least one lateral lip. Additionally, the projection holding section includes at least one lateral depression adjacent to the at least one lateral ledge for releasably engaging the at least one sidewall of the projection.

[0016] Although these features are intended to encompass any suitable configuration, in a preferred embodiment, the at least one sidewall is curved and the at least one depression is curved wherein these elements are aligned, snapped-fit or interlock in a puzzle-lock manner. Moreover, the lateral arms of the base connect directly to the interconnecting elements of the lattice.

[0017] The stent of the present invention is directed toward both a balloon actuated stent and a self-expanding stent. The stent is made of any suitable material. In one embodiment, the stent is made of an alloy such as stainless steel. In another preferred embodiment, the stent is made of a nickel titanium based alloy. Moreover, this material or any other super-elastic alloy is suitable for the stent according to the present invention. In these self-expanding stent embodiments, the stent is a crush recoverable stent.

[0018] The present invention is also directed toward an apparatus and method for stenting a vessel utilizing the stent embodiments described above, e.g., a stent having a lattice of interconnecting elements and including interlocking features such as a plurality of interlocking bridges in one embodiment or a plurality of interlocking struts in another embodiment.

[0019] The apparatus further includes a catheter having an inner sleeve and an expandable member on the inner sleeve wherein the expandable member is movable between a collapsed state and an expanded state. One of the stent embodiments described above is secured to the catheter over the expandable member when the expandable member is in the collapsed state and the stent is in the locked configuration. The stent is separated or deployed from the catheter when the expandable member is in the expanded state and the stent is in the open configuration. The apparatus further includes a cover movably disposed over the stent. The cover is an outer sheath made of a polymer material. Additionally, the expandable member is an inflatable balloon.

[0020] The apparatus according to the present invention, according to either embodiment, e.g., the interlocking bridge embodiment or the interlocking strut embodiment, is used in a method in which it is inserted within a vessel. The distal end of the apparatus is positioned at a desired location within the vessel and the stent is deployed to the open configuration with the expandable member.

[0021] The method includes providing the cover movably disposed over the stent for preventing the stent from moving to the open configuration until desired. The method further includes deploying the stent to the open configuration by inflation of the expandable member.

[0022] Additionally, the method includes securing the stent to the catheter by interlocking the bridges (for the interlocking bridge embodiment) or by interlocking the struts (for the interlocking strut embodiment) prior to performing certain steps according to the present invention. Lastly, the method according to the present invention also comprises removing the catheter from the patient after the deployment of the stent.

[0023] Accordingly, the invention provides a method for stenting a vessel comprising the steps of:

(a) providing an apparatus comprising:

(i) a stent having a lattice of interconnecting elements defining a substantially cylindrical configuration having a first open end and a second open end, the lattice being movable between a closed configuration and an open configuration, and a plurality of bridges connecting the interconnecting elements, each bridge interlocking with an adjacent bridge in the locked configuration and each bridge separating from the adjacent bridge in the open configuration;
(ii) a catheter having an inner sleeve and an expandable member on the inner sleeve, the expandable member being movable between a collapsed state and an expanded state, the stent being secured to the catheter over the expandable member when the expandable member is in the collapsed state and the stent is in the locked configuration and the stent being separated from the catheter when the expandable member is in the expanded state and the stent is in the open configuration;

(b) inserting the apparatus within a vessel;
(c) positioning the distal end of the apparatus at a desired location within the vessel; and
(d) deploying the stent to the open configuration with the expandable member.

[0024] In another aspect, the invention provides a method for stenting a vessel comprising the steps of:

(a) providing an apparatus comprising:

(i) a stent having a lattice of interconnecting elements defining a substantially cylindrical configuration having a first open end and a second open end, the lattice being movable between a closed configuration and an open configuration, and a plurality of struts connecting the interconnecting elements, each strut interlocking with an adjacent strut in the locked configuration and each strut separating from the adjacent strut in the open configuration;
(ii) a catheter having an inner sleeve and an expandable member on the inner sleeve, the expandable member being movable between a collapsed state and an expanded state, the stent being secured to the catheter over the expandable member when the expandable member is in the collapsed state and the stent is in the locked configuration and the stent being

separated from the catheter when the expandable member is in the expanded state and the stent is in the open configuration.

(b) inserting the apparatus within a vessel;
(c) positioning the distal end of the apparatus at a desired location within the vessel; and
(d) deploying the stent to the open configuration with the expandable member.

[0025] Preferably, the catheter includes a cover movably disposed over the stent wherein the cover prevents the stent from moving to the open configuration during steps (a)-(c). Preferably, the method includes the step of deploying the stent to the open configuration by inflation of the expandable member. Preferably, the method includes the step of securing the stent to the catheter by interlocking the bridges prior to performing steps (b)-(d), and preferably also the step of removing the catheter after performing step (d).

[0026] Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings, in which:

Fig 1A is a perspective view of a first embodiment of a stent in a closed configuration in accordance with the present invention;
Fig 1B is a perspective view of a second embodiment of a stent in a closed configuration in accordance with the present invention;
Fig 2A is a partial side plan view of an interlocking bridge for the stent of Fig 1A;
Fig 2B is a partial side plan view of an interlocking strut for the stent of Fig 1B;
Fig 3A is a partial side view of the lattice of the stent of Fig 1A;
Fig 3B is a partial side view of the lattice of the stent of Fig 1B;
Fig 4A is a partial perspective view of the stent of Fig 1A in an open configuration;
Fig 4B is a partial perspective view of the stent of Fig 1B in an open configuration;
Fig 5A is a partial perspective view of a distal end of an apparatus according to the present invention utilizing the stent of Fig 1A; and
Fig 5B is a partial perspective view of a distal end of an apparatus according to the present invention utilizing the stent of Fig 1B.

[0027] Referring to the drawings, Figs. 1A, 1B, 4A and 4B show a stent 100 that is an expandable prosthesis for a body passageway. It should be understood that the terms "stent" and "prosthesis" are interchangeably used to some extent in describing the present invention, insofar as the method, apparatus, and structures of the present invention may be utilized not only in connection with an expandable intraluminal vascular graft for expanding partially occluded segments of a blood vessel, duct or body passageways, such as within an organ, but may so be utilized for many other purposes as an expandable prosthesis for many other types of body passageways. For example, expandable prostheses may also be used for such purposes as: (1) supportive graft placement within blocked arteries opened by transluminal recanalization, but which are likely to collapse in the absence of internal support; (2) similar use following catheter passage through mediastinal and other veins occluded by inoperable cancers; (3) reinforcement of catheter created intrahepatic communications between portal and hepatic veins in patients suffering from portal hypertension; (4) supportive graft placement of narrowing of the esophagus, the intestine, the ureters, the uretha, etc.; (5) intraluminally bypassing a defect such as an aneurysm or blockage within a vessel or organ; and (6) supportive graft reinforcement of reopened and previously obstructed bile ducts. Accordingly, use of the term "prosthesis" encompasses the foregoing usages within various types of body passageways, and the use of the term "intraluminal graft" encompasses use for expanding the lumen of a body passageway. Further in this regard, the term "body passageway" encompasses any lumen or duct within the human body, such as those previously described, as well as any vein, artery, or blood vessel within the human vascular system.

[0028] The stent 100 is an expandable lattice structure made of any suitable material which is compatible with the human body and the bodily fluids (not shown) with which the stent 100 may come into contact. The lattice structure is an arrangement of interconnecting elements made of a material which has the requisite strength and elasticity characteristics to permit the tubular shaped stent 100 to be expanded from the closed configuration shown in Figs. 1A and 1B to the expanded configuration shown in Figs. 4A and 4B and further to permit the stent 100 to retain its expanded configuration at the enlarged diameter d_1. Suitable materials for the fabrication of the stent 100 include silver, tantalum, stainless steel, gold, titanium or any suitable plastic material having the requisite characteristics previously described. In one embodiment, the stent is fabricated from 316L stainless steel alloy

[0029] In a preferred embodiment, the stent 100 comprises a superelastic nickel titanium based alloy. More preferably, the stent 100 is formed from an alloy comprising from about 50.5 to 60.0% Ni by atomic weight and the remainder Ti. Even more preferably, the stent 100 is formed from an alloy comprising about 55% Ni and about 45% Ti. The stent 100 is preferably designed such that it is superelastic at body temperature, and preferably has an A_f temperature in the range from about 24°C to about 37°C. The superelastic design of the stent 100 makes it crush recoverable and thus suitable as a stent or frame for any number of vascular devices for different applications.

[0030] The stent 100 comprises a tubular configuration formed by a lattice of interconnecting elements de-

fining a substantially cylindrical configuration and having front and back open ends 102, 104 and defining a longitudinal axis 103 extending between them. In its closed configuration, the stent 100 has a first diameter (d_1) for insertion into a patient and navigation through the vessels and, in its open configuration, a second diameter (d_2), as shown in Figs. 4A and 4B, for deployment into the target area of a vessel with the second diameter being greater than the first diameter. The stent 100 comprises a plurality of adjacent hoops 106(a)-(d) extending between the front and back ends 102, 104. The hoops 106(a)-(d) include a plurality of longitudinally arranged struts 108 and a plurality of loops 110 connecting adjacent struts 108. Adjacent struts 108 are connected at opposite ends so as to form a substantially S or Z shape pattern. The plurality of loops 110 have a substantially semi-circular configuration and are substantially symmetric about their centres.

[0031] The stent 100 further comprises a plurality of bridges 114, which connect adjacent hoops 106(a)-(d). The details of the bridges 114 are more fully illustrated in Figs. 2A, and 3A and described below. Each bridge comprises two ends wherein one end of each bridge 114 is attached to one loop 110 on one hoop 106(a) and the other end of each bridge 114 is attached to one loop 110 on an adjacent hoop 106(b). The bridges 114 connect adjacent hoops 106(a)-(d) together at bridge to loop connection regions 120,122 as shown in Fig. 2A.

[0032] The above-described geometry better distributes strain throughout the stent 100, prevents metal to metal contact where the stent 100 is bent, and minimizes the opening between the features of the stent 100; namely, struts 108, loops 110 and bridges 114. The number of and nature of the design of the struts, loops and bridges are important design factors when determining the working properties and fatigue life properties of the stent 100. It was previously thought that in order to improve the rigidity of the stent, struts should be large, and thus there should be fewer struts 108 per hoop 106 (a)-(d). However, it is now known that stents 100 having smaller struts 108 and more struts 108 per hoop 106(a) -(d) improve the construction of the stent 100 and provide greater rigidity. Preferably, each hoop 106(a)-(d) has between twenty-four (24) to thirty-six (36) or more struts 108. It has been determined that a stent having a ratio of number of struts per hoop to strut length which is greater than four hundred has increased rigidity over prior art stents which typically have a ratio of under two hundred. The length of a strut is measured in its compressed state parallel to the longitudinal axis 103 of the stent 100 as illustrated in Fig. 1A.

[0033] Fig. 4A illustrates the stent 100 in its open or expanded state. As may be seen from a comparison between the stent 100 configuration illustrated in Fig. 1A and the stent 100 configuration illustrated in Fig. 4A, the geometry of the stent 100 changes quite significantly as it is deployed from its unexpanded state (closed or locked configuration) to its expanded state (open or unlocked configuration). As the stent 100 undergoes diametric change, the strut angle and strain levels in the loops 110 and bridges 114 are affected. Preferably, all of the stent features will strain in a predictable manner so that the stent 100 is reliable and uniform in strength. In addition, it is preferable to minimize the maximum strain experienced by the struts 108, loops 110 and bridges 114 since the properties of nickel titanium alloys are more generally limited by strain rather than by stress. The embodiments illustrated in Figs. 1A to 5B has a design to help minimize forces such as strain.

[0034] Fig. 1A illustrates the first embodiment of the stent 100 according to the present invention including a plurality of interlocking bridges 114 connecting adjacent hoops 106(a)-(d). In this embodiment, as best illustrated in Fig. 2A, stent 100 has bridges 114 wherein each bridge 114 includes a base 126. The base 126 has a pair of laterally extending arms 128 wherein each end of the lateral arms 128 are connected directly to a loop 110 at loop connection regions 120 and 122. Accordingly, one laterally extending arm connects to one of the adjacent hoops 106(a)-(d) at the loop connection region 120 of one loop 110 and the other lateral extending arm 128 of the bridge 114 is connected to an adjacent loop 110 at the loop connection region 122. Thus, the bridge 114 alternatively connects adjacent hoops 106(a)-(d).

[0035] The bridge 114 further includes an extension 130 extending in a superior direction from the base 126. The extension 130 includes a neck 131 at the superior end of the extension 130. A projection 132 is fixed to the superior end of the neck 131 of the extension 130. Although the projection 132 can comprise any desired configuration, one preferred configuration for the projection 132 includes a pair of lateral lips 134 laterally extending from the neck 131 and a pair of lateral sidewalls 136 extending from the lateral lips 134 respectively. In this embodiment, the lateral sidewalls 136 have a curved-shape. Additionally, the projection 132 further includes an upper edge 137 extending between the lateral sidewalls 136.

[0036] The bridge 114 further includes a projection holding section 140 inferior to the extension 130 at the base 126. The projection holding section 140 is defined by an opening 142 in the base 126. The projection holding section 140 further includes a pair of lateral ledges 144 extending from each side of the opening 142. The projection holding section 140 further includes a lateral depression 146 extending from each lateral ledge 144. Each lateral depression 146 also has a curved-shape for this embodiment. Additionally, the projection holding section 140 includes an upper edge 147 extending between each lateral depression 146.

[0037] The projection holding section 140 is shaped to fit and receive in a snap-fit or puzzle-lock manner the projection 132 of an adjacent bridge 114. Due to the unique configuration of the bridge 114, the projection 132 of a first bridge 114 is interlocked with the projection holding section 140 of a second bridge 114. The inter-

locking of bridges 114, which can be adjacent bridges, is accomplished by insertion of the projection 132 of the first bridge 114 into the central opening 142 of the projection holding section 140 of the second bridge 114 such that the lateral lips 134 releasably engage the lateral ledges 144 of the projection holding section 140. Moreover, the lateral sidewalls 136 of the projection 132 mates, in a releasable fashion, with the lateral depressions 146 of the projection holding section 140 of the second bridge 114. Furthermore, the upper edge 137 of the projection 132 of the first bridge 114 releasably mates with the upper edge 147 of the projection holding section 140 of the second bridge 114. Accordingly, this arrangement insures for an interlocking of the first and second bridges 114, e.g., adjacent bridges 114, in a puzzle-like manner. This arrangement of interlocking bridges 114 is clearly illustrated in Fig. 3A. When deployed to an open configuration, the stent 100 for the interlocking bridge embodiment described above expands to a width D_2 as shown in Fig 4A.

[0038] A second embodiment for the stent 100 is shown in Fig. 1B and includes a plurality of interlocking struts 108a. In this embodiment, adjacent hoops 106(a) -(d) are connected to each other by nonlocking bridges 114a.

[0039] For the embodiment of Fig. 1B (the interlocking strut embodiment), a plurality of interlocking struts 108a are utilized in order to interlock by releasable engagement a first strut 108a with a second strut 108a as best shown in Fig. 3B.

[0040] For purposes of this disclosure, the same reference numerals are used to designate like or similar features for both the interlocking bridge 114 embodiment (Fig. 1A) and the interlocking strut 108a embodiment (Fig. 1B). Accordingly, each interlocking strut 108a includes base 126 and laterally extending sidearms 128 as shown in Fig 2B.

[0041] As illustrated in Fig. 2B, the strut 108a further includes extension 130 extending in a superior direction from the base 126. Projection 132 is fixed to the superior end of the extension 130. Although the projection 132 can comprise any desired configuration, one preferred configuration for the projection 132 includes a pair of lateral lips 134 laterally extending from the extension 130 and a pair of lateral sidewalls 136 extending from the lateral lips 134 respectively. In this embodiment, the lateral sidewalls 136 have a curved-shape. Additionally, the projection 132 further includes upper edge 137 extending between the sidewalls 136.

[0042] The strut 108a (of the interlocking strut embodiment) further includes projection holding section 140 inferior to the extension 130 at the base 126. The projection holding section 140 is defined by opening 142 in the base 126. The projection holding section 140 further includes a pair of lateral ledges 144 extending from each side of the opening 142. The projection holding section 140 further includes lateral depression 146 extending from each lateral ledge 144. Each lateral depression 146 also has a curved-shape for this embodiment. Additionally, the projection holding section 140 includes upper edge 147 extending between each lateral depression 146.

[0043] As best illustrated in Fig. 3B, the projection holding section 140 is shaped to fit and receive in a snap-fit or puzzle-lock manner the projection 132 of an adjacent strut 108a. Due to the unique configuration of the strut 108a, the projection 132 of a first strut 108a is interlocked with the projection holding section 140 of a second strut 108a. The interlocking of struts 108a, which can be adjacent struts, is accomplished by insertion of the projection 132 of the first strut 108a into the central opening 142 of the projection holding section 140 of the second strut 108a such that the lateral lips 134 releasably engage the lateral ledges 144 of the projection holding section 140. Moreover, the lateral sidewalls 136 of the projection 132 mates, in a releasable fashion, with the lateral depressions 146 of the projection holding section 140 of the second strut 108a. Furthermore, the upper edge 137 of the projection 132 of the first strut 108a releasably mates with the upper edge 147 of the projection holding section 140 of the second strut 108a. Accordingly, this arrangement insures for an interlocking of the first and second struts 108a, e.g., adjacent struts 108a, in a puzzle-like manner. This arrangement of interlocking struts 108a is clearly illustrated in Fig. 3B. Thus, the first strut 108a releasably engages with or interlocks with the second strut 108a in a puzzle-lock manner.

[0044] As mentioned above with the interlocking bridge embodiment of Fig. 4A, as shown in Fig. 4B, the stent 100 having the interlocking struts 108a (the interlocking strut embodiment) is deployed or expanded to an open configuration having a width D_2.

[0045] The stent 100 according to the present invention for both the interlocking bridge 114 embodiment and the interlocking strut 108a embodiment is directed toward both deployment or expansion through an expandable member such as a balloon (to be described in greater detail below) and a self-expanding stent, i.e., a stent that is crush recoverable.

[0046] The present invention also includes an apparatus and method for stenting a vessel utilizing the stent 100 (both the interlocking bridge 114 embodiment and the interlocking strut 108a embodiment). The stenting apparatus according to the present invention is generally designated 200 as best shown in Figs. 5A and 5B. Fig. 5A illustrates the apparatus 200 (as a catheter) which includes the stent 100 (the interlock bridge 114 embodiment) and Fig. 5B illustrates the apparatus 200 including the second embodiment for the stent 100 (the interlocking strut 108a embodiment). As illustrated in Figs. 5A and 5B, the catheter 200 has a distal end 210 culminating in a distal tip 215. The catheter 200 includes an inner sleeve 220 extending to the distal tip 215. An expandable member 230, such as an inflatable balloon, is fixed to the inner sleeve 220 at the distal end 210 of

the catheter 200. As is well understood in the field, the expandable member 230 is expanded, such as through inflation with a hydraulic or pneumatic fluid, and is expandable from a collapsed or closed configuration to an open or expanded configuration. The stent 100 (both embodiments of Figs. 1A and 1B) according to the present invention are secured to the distal end of the catheter 200 by closing the stent 100 over the expandable member 230 and the inner sleeve 220 as best illustrated in Figs. 5A and 5B. The stent 100 is secured to the catheter 200 by closing the stent 100 respectively by moving the stent 100 and to its locked configuration. As described above, the locked configuration for the stent 100 includes interlocking the bridges 114 (for the interlocking bridge embodiment Fig. 5A) and for interlocking the struts 108a (for the interlocking strut embodiment Fig. 5B) in the respective manner described above.

[0047] In securing the stent 100 to the catheter distal end 210 for the interlocking bridge embodiment of Fig. 5A, the bridges 114 are moved and interlocked (as shown in Fig. 3A) such that the stent 100 is locked and in its closed configuration over the expandable member 230.

[0048] In securing the stent 100 to the catheter distal end 210 for the interlocking strut embodiment of Fig. 5B, the struts 108a are moved and interlocked (as shown in Fig. 3B) such that the stent 100 is locked and in its closed configuration over the expandable member 230.

[0049] For both embodiments mentioned above, the stent 100 is thereby secured to the catheter 200 until deployment is desired. An outer sheath 240, which is made of a polymer material such as polyethylene, is used as a cover for the catheter distal end 210 and serves as an additional form of protection for securing of the stent 100 (both embodiments) to the catheter distal end 210. The cover 240 is movably positioned or movably disposed from the catheter distal end 210 in order to provide both the protection as described above as well as the unimpeded deployment of the stent 100 upon positioning of the stent 100 at its desired location.

[0050] The method of utilizing the catheter 200 according to the present invention includes first identifying a location in a patient's body for deployment of the stent 100. Upon identifying the desired deployment location, the catheter 200 is inserted within a vessel in the patient's body. The catheter 200 is used to traverse the vessel until reaching the desired location wherein the distal end 210 of the catheter 200 is positioned at the desired location within the vessel. At this point, the stent 100 is deployed to its open configuration by expanding the expandable member 230 such as by inflation. If the cover 240 is utilized to further protect and secure the stent 100 to the catheter distal end 210, the cover 240 is removed from the distal end 210 prior to expansion of the expandable member 230.

[0051] Upon expanding the stent 100 to its open configuration, the expandable member 230 is then collapsed, for instance through deflation of the expandable member, whereby the catheter 200 is removed from the deployment site of the vessel and patient's body altogether.

Claims

1. An apparatus for stenting a vessel comprising:

   (i) a stent (100) having a lattice of interconnecting elements defining a substantially cylindrical configuration having a first open end (102) and a second open end (104), wherein the lattice is movable between a locked configuration and an open configuration, and a plurality of bridges (114) connecting the interconnecting elements, wherein each bridge (114) interlocks with an adjacent bridge (114) in the locked configuration and each bridge (114) separates from the adjacent bridge (114) in the open configuration;
   (ii) a catheter (200) having an inner sleeve (220) and an expandable member (230) on the inner sleeve (200), wherein the expandable member is movable between a collapsed state and an expanded state,

   wherein the stent (100) is secured to the catheter (200) over the expandable member (230) when the expandable member (230) is in the collapsed state and the stent (100) is in the locked configuration; and wherein the stent (100) is separated from the catheter (200) when the expandable member (230) is in the expanded state and the stent (100) is in the open configuration.

2. An apparatus for stenting a vessel comprising:

   (i) a stent (100) having a lattice of interconnecting elements defining a substantially cylindrical configuration having a first open end (102) and a second open end (104), wherein the lattice is movable between a locked configuration and an open configuration, wherein the interconnecting elements include a plurality of struts, (108a) and each strut (108a) interlocks with an adjacent strut (108a) in the locked configuration and each strut (108a) separates from the adjacent strut in the open configuration;
   (ii) a catheter (200) having an inner sleeve (220) and an expandable member (230) on the inner sleeve (220), wherein the expandable member (230) is movable between a collapsed state and an expanded state,

   wherein the stent (100) is secured to the catheter (200) over the expandable member (230) when the expandable member (230) is in the collapsed

state and the stent (100) is in the locked configuration; and wherein the stent (100) is separated from the catheter (200) when the expandable member (230) is in the expanded state and the stent (100) is in the open configuration.

3. Apparatus as claimed in claim 1 or 2, wherein the catheter includes a cover (240) movably disposed over the stent (100).

4. Apparatus as claimed in claim 1 or 2, wherein the expandable member (230) is an inflatable balloon.

5. Apparatus as claimed in claim 4, wherein the cover (240) is an outer sheath.

6. Apparatus as claimed in claim 5, wherein the sheath is made of a polymer.

7. Apparatus as claimed in claim 1 or 2, wherein the stent (100) is made of an alloy.

8. Apparatus as claimed in claim 7, wherein the stent (100) is made of stainless steel.

9. Apparatus as claimed in claim 1 or 2, wherein the stent (100) is crush recoverable.

10. Apparatus as claimed in claim 9, wherein the stent (100) comprises a nickel titanium based alloy.

11. Apparatus as claimed in claim 7, wherein the stent (100) is made of a superelastic alloy.

12. Apparatus as claimed in claim 11, wherein the stent (100) comprises a nickel titanium based alloy.

13. Apparatus as claimed in claim 1 or 2, wherein each bridge (114) or stent (108a) has a projection (132) and a base (126), the base having a projection holding section (140) for receiving the projection (132) from the adjacent bridge (114) or strut (108a).

14. Apparatus as claimed in claim 13, wherein the interconnecting elements comprise a plurality of adjacent sections.

15. Apparatus as claimed in claim 14, wherein the adjacent sections comprise adjacent hoops.

16. Apparatus as claimed in claim 15, wherein each hoop comprises a plurality of loops.

17. Apparatus as claimed in claim 16, wherein each hoop comprises at least one strut.

18. Apparatus as claimed in claim 14, wherein each bridge (114) or strut (108a) has lateral arms (128) extending from the base (126).

19. Apparatus as claimed in claim 18, wherein the projection holding section (140) has an opening therein.

20. Apparatus as claimed in claim 19, wherein an extension (130) is connected between the base (126) and the projection (132).

21. Apparatus as claimed in claim 20 when appendant to claim 1, wherein the extension (130) includes a neck (131) and the projection (132) is located at a superior position on the neck (131).

22. The apparatus according to Clam 21, wherein the projection (132) includes at least one lateral lip (134).

23. Apparatus as claimed in claim 22, wherein the projection holding section (140) includes at least one lateral ledge (144) for releasable engaging the at least one lateral lip (134) of the projection (132).

24. Apparatus as claimed in claim 23, wherein the projection (132) includes at least one sidewall adjacent the at least one lateral lip.

25. Apparatus as claimed in claim 24, wherein the projection holding section (140) includes at least one lateral depression adjacent the at least one lateral ledge for releasably engaging the at least one sidewall of the projection.

26. Apparatus as claimed in claim 25, wherein the at least one sidewall is curved.

27. Apparatus as claimed in claim 26, wherein the at least one depression is curved.

28. Apparatus as claimed in claim 27, wherein the lateral arms (128) connect the interconnecting elements.

Patentansprüche

1. Vorrichtung zum Stützen eines Gefäßes, die folgendes umfaßt:

   (i) einen Stent (100) mit einem Gitter von Verbindungselementen, die eine im wesentlichen zylindrische Konfiguration mit einem ersten offenen Ende (102) und einem zweiten offenen Ende (104) festlegen, wobei das Gitter zwischen einer verriegelten Konfiguration und einer offenen Konfiguration beweglich ist, und mit mehreren Brücken (114), die die Verbindungs-

elemente verbinden, wobei jede Brükke (114) mit einer benachbarten Brücke (114) in der verriegelten Konfiguration ineinandergreift und jede Brücke (114) von der benachbarten Brücke (114) in der offenen Konfiguration beabstandet ist;
(ii) einen Katheter (200) mit einer inneren Hülse (220) und einem aufweitbaren Element (230) auf der inneren Hülse (200), wobei das aufweitbare Element zwischen einem zusammengezogenen Zustand und einem aufgeweiteten Zustand beweglich ist,

wobei der Stent (100) an dem Katheter (200) über dem aufweitbaren Element (230) gesichert ist, wenn sich das aufweitbare Element (230) in dem zusammengezogenen Zustand und der Stent (100) in der verriegelten Konfiguration befinden, und wobei der Stent (100) von dem Katheter (200) beabstandet ist, wenn sich das aufweitbare Element (230) in dem aufgeweiteten Zustand und der Stent (100) in der offenen Konfiguration befmden.

2. Vorrichtung zum Stützen eines Gefäßes, die folgendes umfaßt:

(i) einen Stent (100) mit einem Gitter von Verbindungselementen, die eine im wesentlichen zylindrische Konfiguration mit einem ersten offenen Ende (102) und einem zweiten offenen Ende (104) festlegen, wobei das Gitter zwischen einer verriegelten Konfiguration und einer offenen Konfiguration beweglich ist, wobei die Verbindungselemente mehrere Streben (108a) umfassen und jede Strebe (108a) mit einer benachbarten Strebe (108a) in der verriegelten Konfiguration ineinandergreift und jede Strebe (108a) von der benachbarten Strebe in der offenen Konfiguration beabstandet ist;
(ii) einen Katheter (200) mit einer inneren Hülse (220) und einem aufweitbaren Element (230) auf der inneren Hülse (220), wobei das aufweitbare Element (230) zwischen einem zusammengezogenen Zustand und einem aufgeweiteten Zustand beweglich ist,

wobei der Stent (100) an dem Katheter (200) über dem aufweitbaren Element (230) gesichert ist, wenn sich das aufweitbare Element (230) in dem zusammengezogenen Zustand und der Stent (100) in der verriegelten Konfiguration befinden, und wobei der Stent (100) von dem Katheter (200) beabstandet ist, wenn sich das aufweitbare Element (230) in dem aufgeweiteten Zustand und der Stent (100) in der offenen Konfiguration befmden.

3. Vorrichtung nach Anspruch 1 oder 2, bei welcher der Katheter eine Abdeckung (240) umfaßt, die beweglich über dem Stent (100) angeordnet ist.

4. Vorrichtung nach Anspruch 1 oder 2, bei welcher das aufweitbare Element (230) ein aufblasbarer Ballon ist.

5. Vorrichtung nach Anspruch 4, bei welcher die Abdeckung (240) eine äußere Umhüllung ist.

6. Vorrichtung nach Anspruch 5, bei welcher die Umhüllung aus einem Polymer hergestellt ist.

7. Vorrichtung nach Anspruch 1 oder 2, bei welcher der Stent (100) aus einer Legierung hergestellt ist.

8. Vorrichtung nach Anspruch 7, bei welcher der Stent (100) aus rostfreiem Stahl hergestellt ist.

9. Vorrichtung nach Anspruch 1 oder 2, bei welcher der Stent (100) auf Druck wiederherstellbar ist.

10. Vorrichtung nach Anspruch 9, bei welcher der Stent (100) eine auf Nickel und Titan basierende Legierung ist.

11. Vorrichtung nach Anspruch 7, bei welcher der Stent (100) aus einer superelastischen Legierung hergestellt ist.

12. Vorrichtung nach Anspruch 11, bei welcher der Stent (100) eine auf Nickel und Titan basierende Legierung umfaßt.

13. Vorrichtung nach Anspruch 1 oder 2, bei welcher jede Brücke (114) oder Strebe (108a) einen Vorsprung (132) und eine Basis (126) aufweist, wobei die Basis einen Haltebereich (140) für einen Vorsprung aufweist, um den Vorsprung (132) von der benachbarten Brücke (114) oder der benachbarten Strebe (108a) aufzunehmen.

14. Vorrichtung nach Anspruch 13, bei welcher die untereinander verbundenen Elemente mehrere benachbarte Bereiche umfassen.

15. Vorrichtung nach Anspruch 14, bei welcher die benachbarten Bereiche benachbarte Reifen umfassen.

16. Vorrichtung nach Anspruch 15, bei welcher jeder Reifen mehrere Schleifen umfaßt.

17. Vorrichtung nach Anspruch 16, bei welcher jeder Reifen wenigstens eine Strebe umfaßt.

18. Vorrichtung nach Anspruch 14, bei welcher jede Brücke (114) oder jede Strebe (108a) seitliche Arme (128) aufweist, die sich von der Basis (126) erstrek-

ken.

19. Vorrichtung nach Anspruch 18, bei welcher der Haltebereich (140) für einen Vorsprung eine Öffnung darin aufweist.

20. Vorrichtung nach Anspruch 19, bei welcher eine Erweiterung (130) zwischen der Basis (126) und dem Vorsprung (132) verbunden ist.

21. Vorrichtung nach Anspruch 20 mit Rückbezug auf Anspruch 1, bei welcher die Erweiterung (130) einen Hals (131) aufweist und der Vorsprung (132) sich an einer oberen Position auf dem Hals (131) befindet.

22. Vorrichtung nach Anspruch 21, bei welcher der Vorsprung (132) wenigstens einen seitlichen Rand (134) umfaßt.

23. Vorrichtung nach Anspruch 22, bei welcher der Haltebereich (140) für einen Vorsprung wenigstens eine seitliche Leiste (144) zum lösbaren Eingreifen mit dem wenigstens einen seitlichen Rand (134) des Vorsprungs (132) umfaßt.

24. Vorrichtung nach Anspruch 23, bei welcher der Vorsprung (132) wenigstens eine Seitenwand angrenzend an dem wenigstens einen seitlichen Rand umfaßt.

25. Vorrichtung nach Anspruch 24, bei welcher der Haltebereich (140) für einen Vorsprung wenigstens eine seitliche Vertiefung angrenzend an der wenigstens einen seitlichen Leiste umfaßt, um lösbar in die wenigstens eine Seitenwand des Vorsprungs einzugreifen.

26. Vorrichtung nach Anspruch 25, bei welcher die wenigstens eine Seitenwand gekrümmt ist.

27. Vorrichtung nach Anspruch 26, bei welcher die wenigstens eine Vertiefung gekrümmt ist.

28. Vorrichtung nach Anspruch 27, bei welcher der seitliche Arm (128) mit den Verbindungselementen verbunden ist.

Revendications

1. Dispositif pour mettre en place une endoprothèse vasculaire dans un vaisseau, comportant :

(i) une endoprothèse vasculaire (100) ayant un treillis d'éléments d'interconnexion définissant une configuration sensiblement cylindrique ayant une première extrémité ouverte (102) et une seconde extrémité ouverte (104), le treillis étant mobile entre une configuration verrouillée et une configuration ouverte, et une pluralité de ponts (114) connectant les éléments d'interconnexion, chaque pont (114) se verrouillant mutuellement avec un pont adjacent (114) dans la configuration verrouillée, et chaque pont (114) se séparant du pont adjacent (114) dans la configuration ouverte ;
(ii) un cathéter (200) ayant un manchon intérieur (220) et un élément pouvant être agrandi (230) sur le manchon intérieur (200), l'élément pouvant être agrandi étant mobile entre un état aplati et un état agrandi,

dans lequel l'endoprothèse vasculaire (100) est fixée sur le cathéter (200) au-dessus de l'élément pouvant être agrandi (230) lorsque l'élément pouvant être agrandi (230) est dans l'état aplati et lorsque l'endoprothèse vasculaire (100) est dans la configuration verrouillée, et dans lequel l'endoprothèse vasculaire (100) est séparée du cathéter (200) lorsque l'élément pouvant être agrandi (230) est dans l'état agrandi et lorsque l'endoprothèse vasculaire (100) est dans la configuration ouverte.

2. Dispositif pour mettre en place une endoprothèse vasculaire dans un vaisseau, comportant :

(i) une endoprothèse vasculaire (100) ayant un treillis d'éléments d'interconnexion définissant une configuration sensiblement cylindrique ayant une première extrémité ouverte (102) et une seconde extrémité ouverte (104), le treillis étant mobile entre une configuration verrouillée et une configuration ouverte, les éléments d'interconnexion comportant une pluralité d'entretoises (108a), et chaque entretoise (108a) se verrouillant mutuellement avec une entretoise adjacente (108a) dans la configuration verrouillée, et chaque entretoise(108a) se séparant de l'entretoise adjacente dans la configuration ouverte ;
(ii) un cathéter (200) ayant un manchon intérieur (220) et un élément pouvant être agrandi (230) sur le manchon intérieur (220), l'élément pouvant être agrandi (230) étant mobile entre un état aplati et un état agrandi,

dans lequel l'endoprothèse vasculaire (100) est fixée sur le cathéter (200) au-dessus de l'élément pouvant être agrandi (230) lorsque l'élément pouvant être agrandi (230) est dans l'état aplati et lorsque l'endoprothèse vasculaire (100) est dans la configuration verrouillée ; et dans lequel l'endoprothèse vasculaire (100) est séparée du cathéter (200) lorsque l'élément pouvant être agrandi (230) est dans l'état agrandi et lorsque l'endoprothèse

vasculaire (100) est dans la configuration ouverte.

3. Dispositif selon la revendication 1 ou 2, dans lequel le cathéter comporte un recouvrement (240) disposé de manière mobile au-dessus de l'endoprothèse vasculaire (100).

4. Dispositif selon la revendication 1 ou 2, dans lequel l'élément gonflable (230) est un ballon gonflable.

5. Dispositif selon la revendication 4, dans lequel le recouvrement (240) est une gaine extérieure.

6. Dispositif selon la revendication 5, dans lequel la gaine est constituée d'un polymère.

7. Dispositif selon la revendication 1 ou 2, dans lequel l'endoprothèse vasculaire (100) est constituée d'un alliage.

8. Dispositif selon la revendication 7, dans lequel l'endoprothèse vasculaire (100) est réalisée en acier inoxydable.

9. Dispositif selon la revendication 1 ou 2, dans lequel l'endoprothèse vasculaire (100) peut être récupérée écrasée.

10. Dispositif selon la revendication 9, dans lequel l'endoprothèse vasculaire (100) comporte un alliage à base de nickel-titane.

11. Dispositif selon la revendication 7, dans lequel l'endoprothèse vasculaire (100) est constituée d'un alliage super-élastique.

12. Dispositif selon la revendication 11, dans lequel l'endoprothèse vasculaire (100) comporte un alliage à base de nickel-titane.

13. Dispositif selon la revendication 1 ou 2, dans lequel chaque pont (114) ou chaque entretoise (108a) a une saillie (132) et une base (126), la base ayant un tronçon de maintien de saillie (140) destiné à recevoir la saillie (132) à partir du pont adjacent (114) ou de l'entretoise adjacente (108a).

14. Dispositif selon la revendication 13, dans lequel les éléments d'interconnexion comportent une pluralité de tronçons adjacents.

15. Dispositif selon la revendication 14, dans lequel les tronçons adjacents comportent des cercles adjacents.

16. Dispositif selon la revendication 15, dans lequel chaque cercle comporte une pluralité de boucles.

17. Dispositif selon la revendication 16, dans lequel chaque cercle comporte au moins une entretoise.

18. Dispositif selon la revendication 14, dans lequel chaque pont (114) ou chaque entretoise (108a) a des bras latéraux (128) s'étendant à partir de la base (126).

19. Dispositif selon la revendication 18, dans lequel le tronçon de maintien de saillie (140) a une ouverture dans celui-ci.

20. Dispositif selon la revendication 19, dans lequel un prolongement (130) est connecté entre la base (126) et la saillie (132).

21. Dispositif selon la revendication 20 lorsque dépendante de la revendication 1, dans lequel le prolongement (130) comporte un col (131), et la saillie (132) est positionnée au niveau d'une position supérieure sur le col (131).

22. Dispositif selon la revendication 21, dans lequel la saillie (132) comporte au moins une lèvre latérale (134).

23. Dispositif selon la revendication 22, dans lequel le tronçon de maintien de saillie (140) comporte au moins un rebord latéral (144) destiné à venir en prise de manière libérable avec la au moins une lèvre latérale (134) de la saillie (132).

24. Dispositif selon la revendication 23, dans lequel la saillie (132) comporte au moins une paroi latérale adjacente à la au moins une lèvre latérale.

25. Dispositif selon la revendication 24, dans lequel le tronçon de maintien de saillie (140) comporte au moins un enfoncement latéral adjacent au au moins un rebord latéral pour venir en prise de manière libérable avec la au moins une paroi latérale de la saillie.

26. Dispositif selon la revendication 25, dans lequel la au moins une paroi latérale est incurvée.

27. Dispositif selon la revendication 26, dans lequel le au moins un enfoncement est incurvé.

28. Dispositif selon la revendication 27, dans lequel les bras latéraux (128) connectent les éléments d'interconnexion.

FIG. 1A

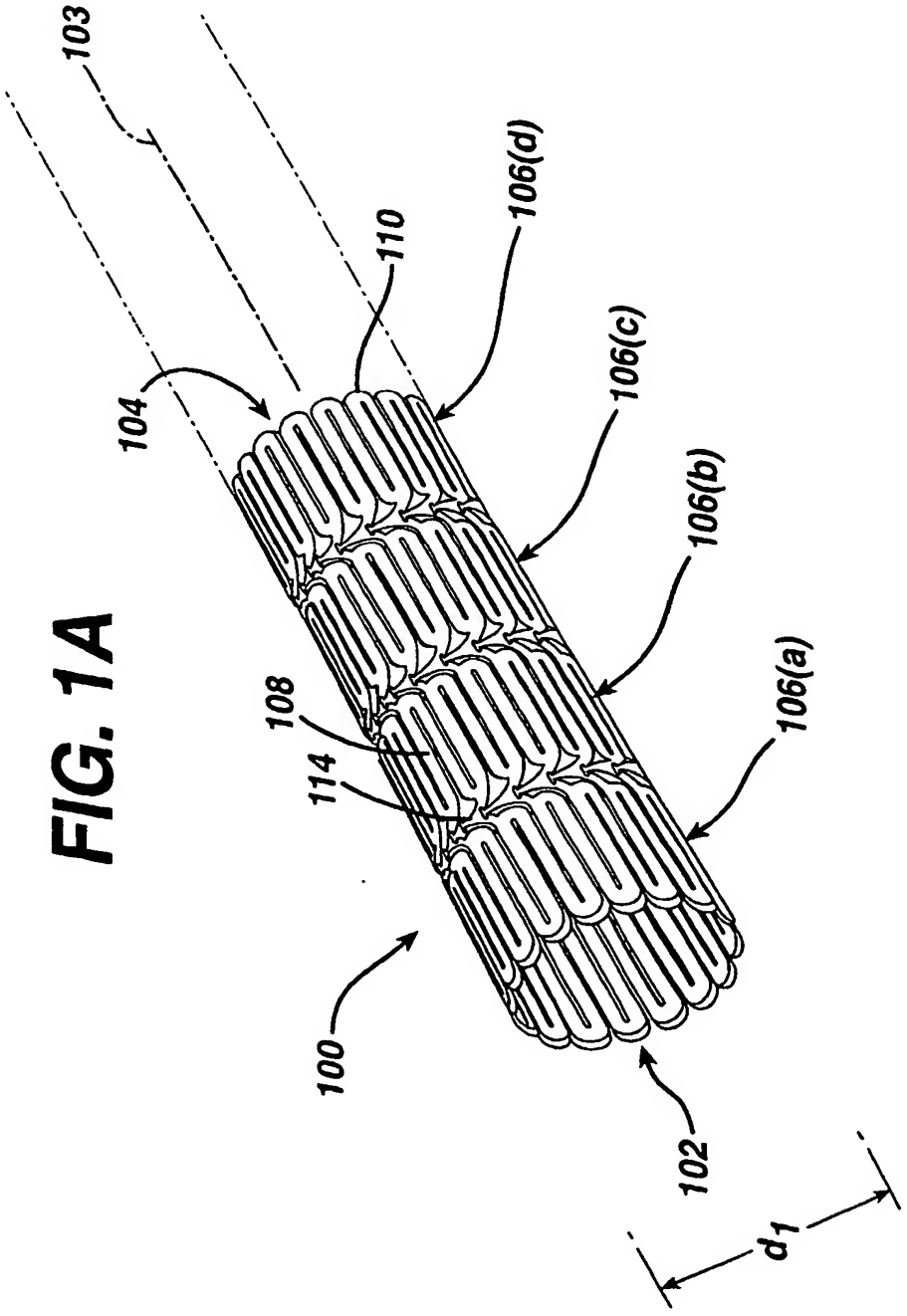


FIG. 1B

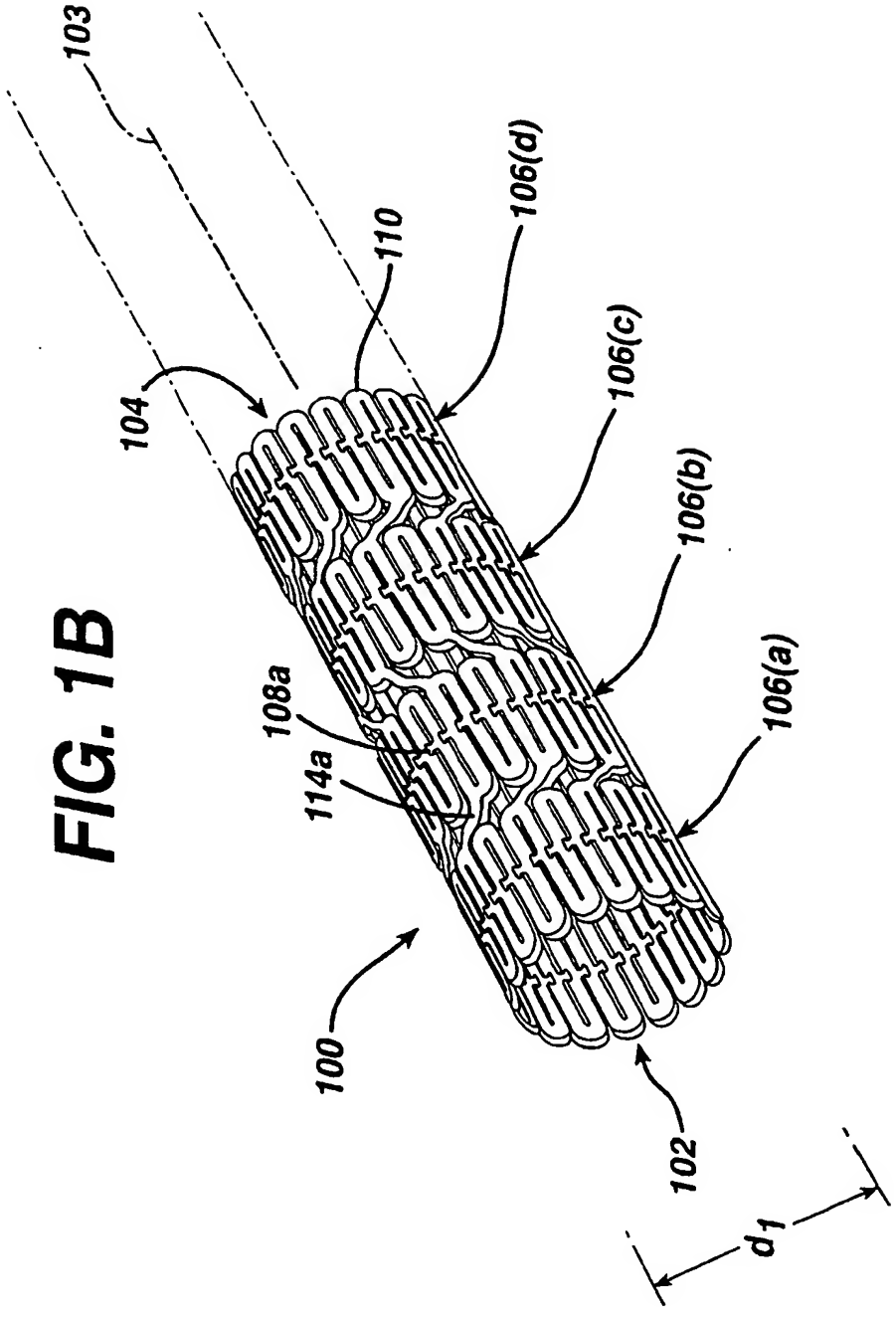


FIG. 2A

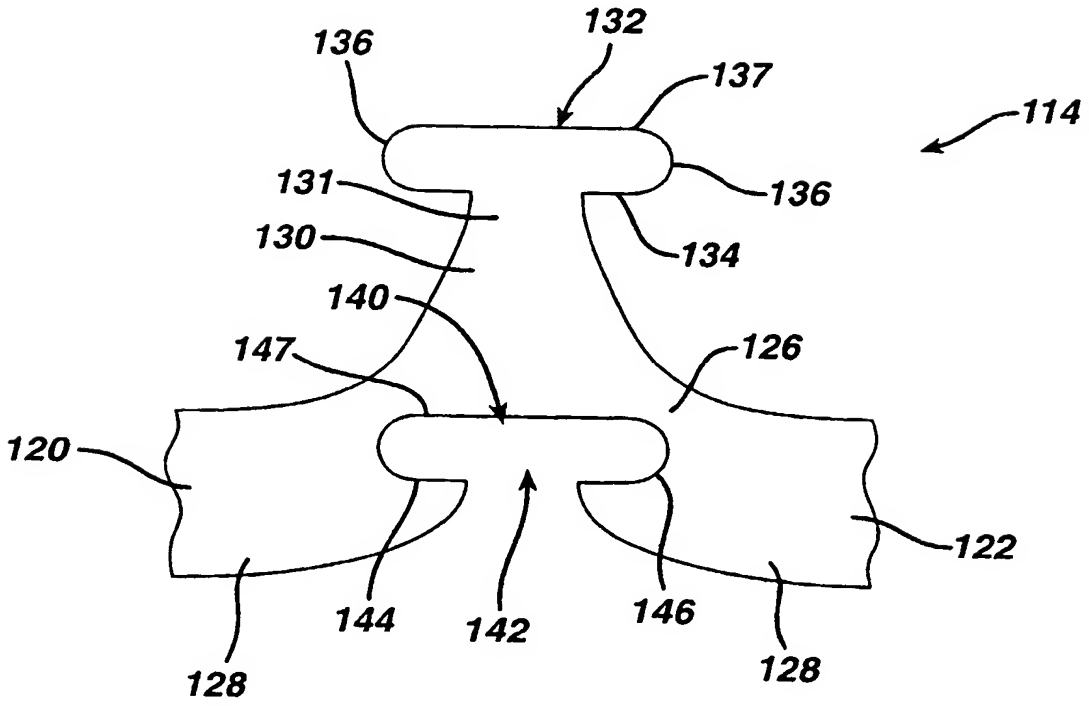

132
136
137
114
131
136
130
134
140
147
126
120
122
144
142
146
128
128

FIG. 2B

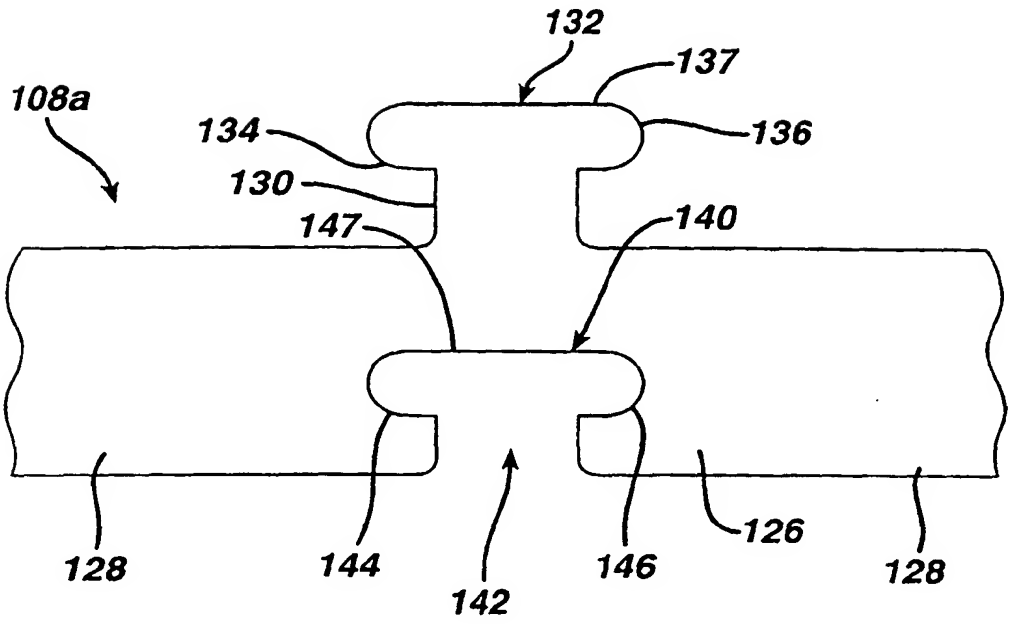


FIG. 3A

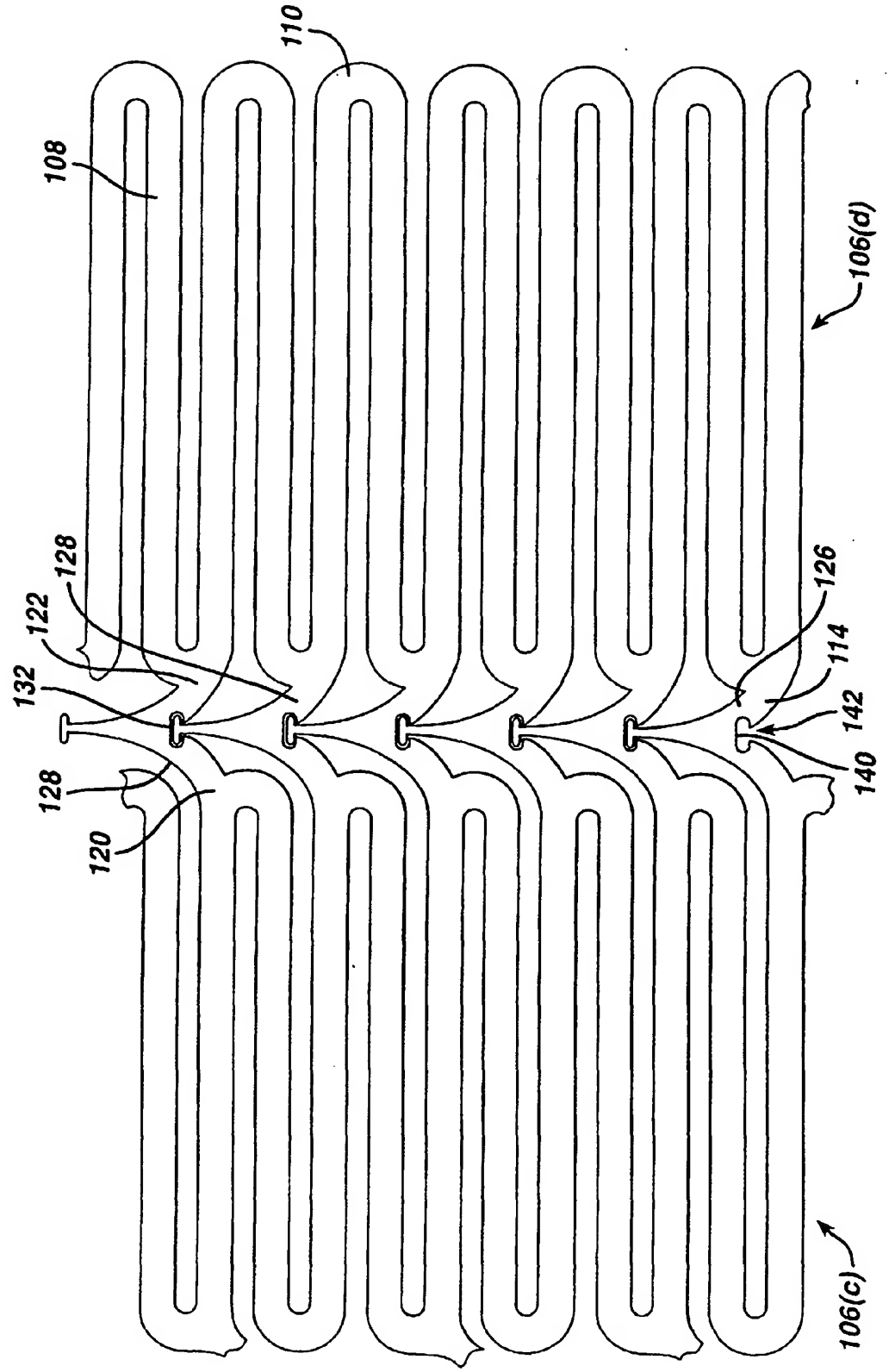


FIG. 3B

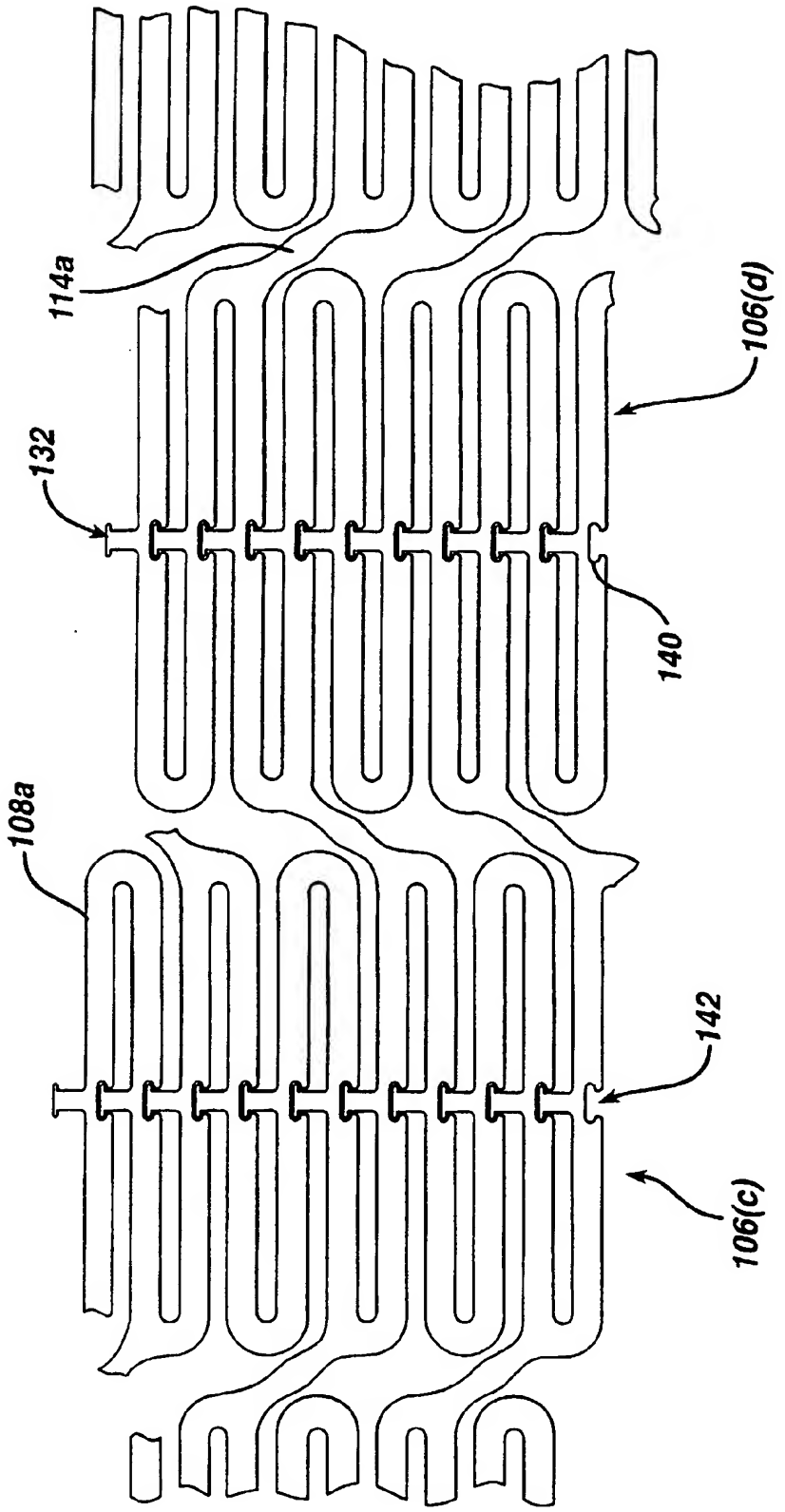


FIG. 4A

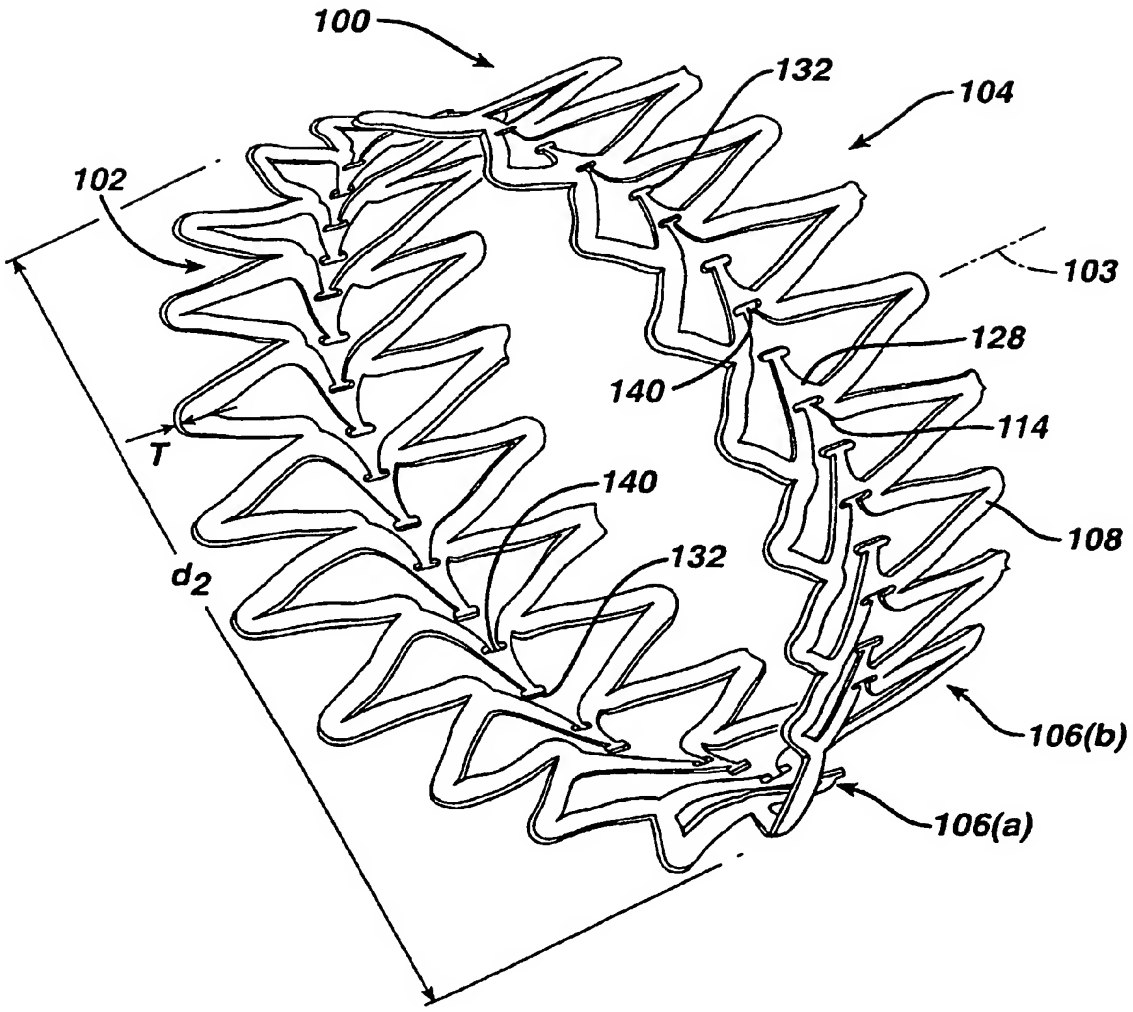
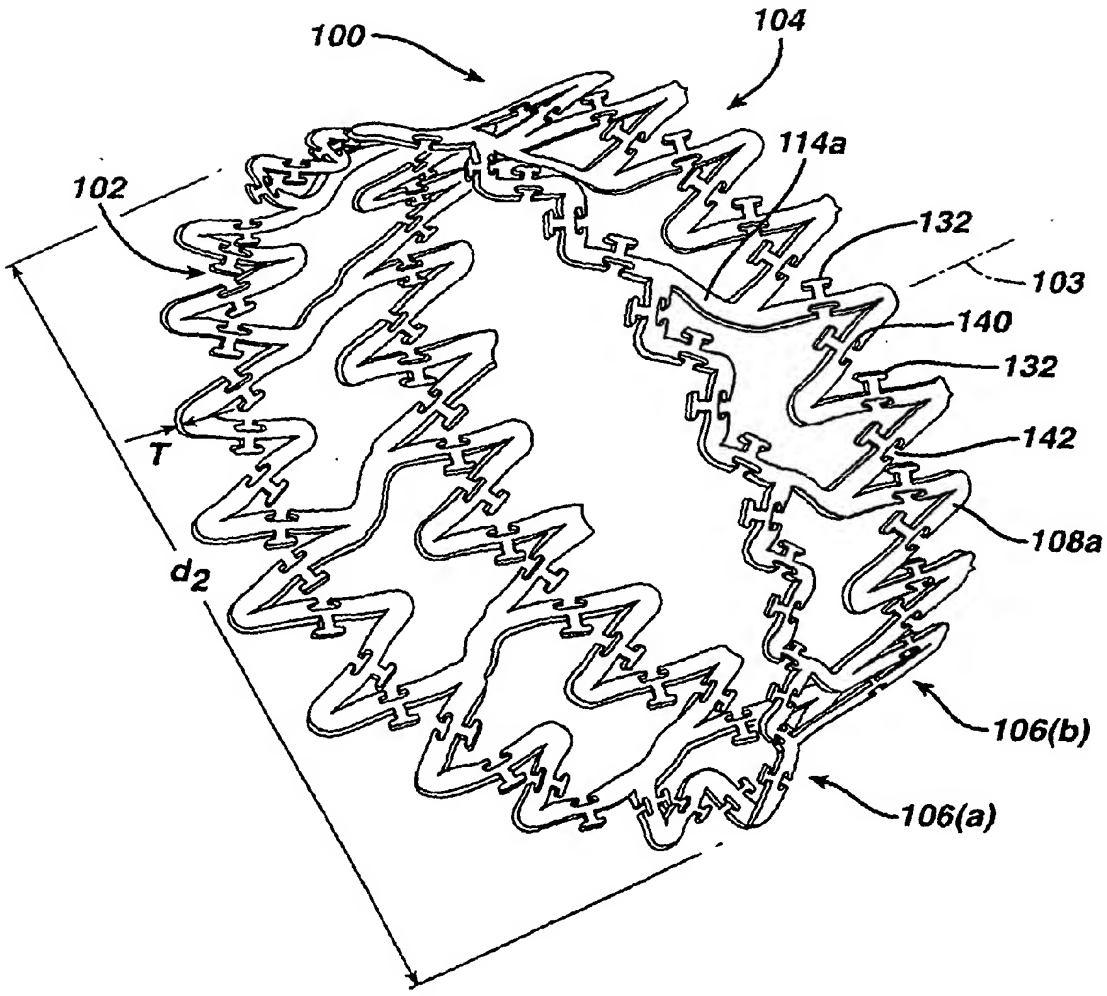


FIG. 4B



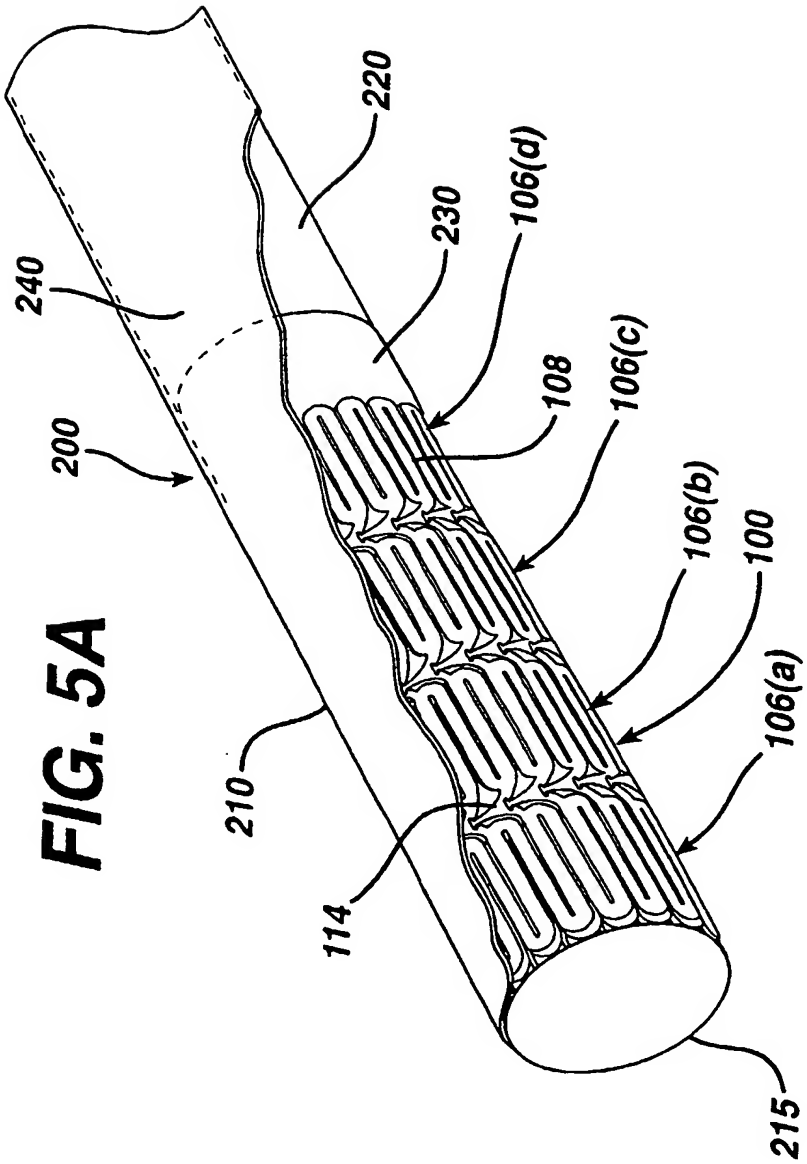


FIG. 5A

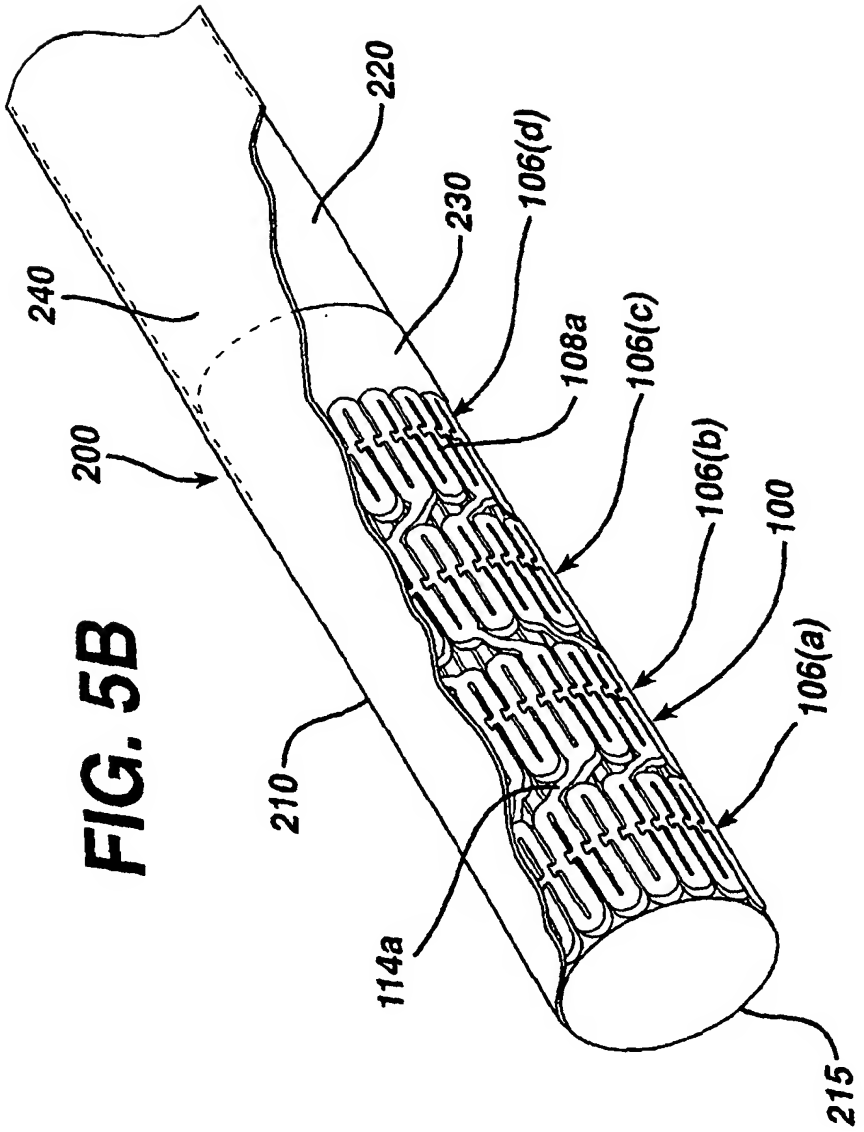


FIG. 5B